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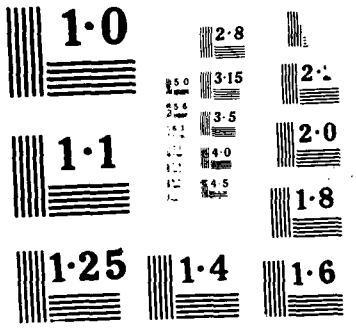
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The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

17 COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Lasers, photochemistry, surface reactions, adsorbates, etching, metals, semiconductors, deposition

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A technique has been developed for determining the surface diffusivity of a weakly bound adsorbate. Electron-beam-induced changes in the structure of partially amorphous CdS surfaces have been observed directly with atomic resolution. The interaction between a visible laser beam and compound semiconductors was studied; a dynamic light-guiding effect which leads to the formation of single mode slab waveguides was identified. Thin films and single crystals of metal oxides were deposited by laser-induced photochemical reactions in gas-phase and adsorbed molecules. A "surface halogenation" technique was developed for the photochemical etching of refractory metal films and was applied to in situ tuning of millimeter-wave circuits. Laser-induced deposition of high-purity tungsten was demonstrated and was applied to multi-level metallization and restructuring of circuits.

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UV-Laser Reactions of Molecular Adsorbates

Final Report

D. J. Ehrlich and M. Rothschild

U. S. Army Research Office

Contract Number: MIPR ARO 131-86

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I. Summary of Accomplishments

This Army Research Office program has supported basic research in the area of laser-induced processes for microfabrication. Work has concentrated on the study of fundamental, area-specific photochemical and photophysical processes in solids and at solid-vapor interfaces. Particular emphasis was placed on effects of adsorbed layers with atomic thickness, and on their role in determining etching and deposition reactions. Below are listed key accomplishments under this program. A list of the relevant publications is also enclosed.

1. The surface diffusion kinetics of weakly bound adsorbates were probed with a spatially localized, UV-laser-driven surface photoreaction, and were theoretically analyzed within a general model using a Green's function integral technique.

2. Thin films of chromium oxide were locally deposited by laser-induced photodecomposition of vapor-phase and adsorbed precursor molecules. It was shown that the nucleation and growth rates were determined by surface adsorption and desorption kinetics.

3. The interaction between bandgap laser radiation and compound II-VI and III-V semiconductors was shown to involve localized heating as well as electron-hole recombination near the surface. At high laser power a unique dynamic light-guiding effect was identified. This leads to the formation of etched structures with submicrometer width and with aspect ratios as high as 50.

4. The temporal evolution of a sequence of electron-beam-induced atomic rearrangements of partially amorphous CdS surfaces was followed with atomic resolution. The fundamental effects of the electron collisions were determined to involve crystallization of CdS and precipitation of Cd crystallites.

5. A low-temperature laser-induced technique for etching of refractory metal films was developed. It was shown that the photochemistry of the surface layers plays a dominant role in the etching kinetics. Laser-controlled chemical surface modification was employed for high-resolution, two-step etching of these films.

6. UV-laser irradiation of GaAs surfaces in chemical ambients was shown to enhance the electrical properties of these surfaces, via surface photochemical reactions.

7. UV-laser etching of crystalline diamond and of diamond-like carbon films was demonstrated to proceed efficiently and with high spatial resolution. With optical projection, 0.13-μm lines and spaces were obtained in these systems.

II. Technology Applications

This Army Research Office program has also supported laser applications in microelectronics in conjunction with additional support from the U. S. Department of the Air Force under a specific program sponsored by the U. S. Air Force Office of Scientific Research, and by the Defense Advanced Research Projects Agency. Below are listed the main results under this program, followed by a list of publications.

1. Tungsten-silicon composite interconnects were obtained in a

two-step process, the first being laser-induced local deposition of silicon. A chemical reaction with tungsten-containing ambient reduced the electrical resistivity of the silicon by a factor of 20.

2. Two-level laser-based metallization on Si and GaAs was achieved by laser-induced deposition of metallic tungsten and laser-induced etching of via holes in the intermetal dielectric. This technique was applied to the reassembly and fabrication of a GaAs digital circuit. The performance of the restructured circuit was as designed, exhibiting stable, reproducible voltage values at both high and low logic levels.

3. This additive/substractive method of laser-induced localized deposition of metallic tungsten and laser-induced localized etching was applied to the accurate trimming of monolithic microwave integrated circuits (MMICs). All other present techniques for tuning MMICs are much slower, less accurate, and with lower yield.

4. The photochemical etching of refractory metal films was applied to in situ tuning of planar millimeter-wave circuits with an accuracy up to 30 times higher than other tuning methods.

5. Laser-based patterning in a step-and-repeat optical projection mode was demonstrated at 0.13-μm resolution, a five-fold improvement over current state-of-the-art optical lithographic techniques. This laser method may supersede conventional (mercury-lamp-based) systems in microelectronics production lines within the next decade.

III. Publications

1. H. J. Zeiger, J. Y. Tsao, and D. J. Ehrlich, "Technique for measuring surface diffusion by laser-beam-localized surface photochemistry," Surf. Sci. 160, 419 (1985).

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4. M. Rothschild, C. Arnone, and D. J. Ehrlich, "Laser photosublimation of compound semiconductors," J. Mater. Res. 2, 244 (1987).

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6. M. Rothschild, J. H. C. Sedlacek, and D. J. Ehrlich, "Laser photochemical etching of molybdenum and tungsten thin films by surface halogenation," Appl. Phys. Lett. 49, 1554 (1986).

7. M. Rothschild, J. H. C. Sedlacek, J. G. Black, and D. J. Ehrlich, "Visible-laser photochemical etching of Cr, Mo, and W," J. Vac. Sci. Technol. B 5, 414 (1987).

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